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Proceedings of the Regional Peer Review Assessment of Atlantic Herring (*Clupea harengus*) in NAFO Divisions 4VWX

March 25-26, 2015
Dartmouth, Nova Scotia

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Foreword

The purpose of these Proceedings is to document the activities and key discussions of the meeting. The Proceedings may include research recommendations, uncertainties, and the rationale for decisions made during the meeting. Proceedings may also document when data, analyses or interpretations were reviewed and rejected on scientific grounds, including the reason(s) for rejection. As such, interpretations and opinions presented in this report individually may be factually incorrect or misleading, but are included to record as faithfully as possible what was considered at the meeting. No statements are to be taken as reflecting the conclusions of the meeting unless they are clearly identified as such. Moreover, further review may result in a change of conclusions where additional information was identified as relevant to the topics being considered, but not available in the timeframe of the meeting. In the rare case when there are formal dissenting views, these are also archived as Annexes to the Proceedings.

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SUMMARY

Atlantic Herring (*Clupea harengus*) is a pelagic species found on both sides of the North Atlantic. The Northwest Atlantic Fisheries Organization (NAFO) 4VWX management unit contains a number of herring spawning areas. For the purposes of evaluation and management, the 4VWX herring fisheries are divided into four components:

1) Southwest Nova Scotia/Bay of Fundy (SWNS/BoF) spawning component (or '4WX' in the management plan);

2) Offshore Scotian Shelf banks spawning component;

3) Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia spawning component; and

4) Southwest New Brunswick (SWNB) migrant juveniles.

The last assessment of 4VWX herring occurred in March 2013 followed by a stock status update undertaken in March, 2014. A 2015 4VWX herring assessment science advisory meeting was held March 25-26, 2015, at the Bedford Institute of Oceanography, Dartmouth, Nova Scotia. Two meeting Working Papers (Acoustic Surveys and 2015 Evaluation) and a Science Advisory Report were presented and discussed at the meeting. The Science Advisory Report did not receive complete review prior to meeting adjournment. It was agreed by meeting participants that the Science lead, meeting Chairperson, and identified DFO peer reviewers would coordinate completion of a draft report consistent with views expressed in the meeting on the Working Papers, and circulated as a revised draft Science Advisory Report by email for subsequent review and approval post-meeting. All comments provided on the circulated report were addressed, and incorporated as necessary, jointly by the science lead and meeting chair. Meeting participants felt the Science Advisory Report and Working Papers presented sound scientific analyses based on the best available information on 4VWX herring. The documents have been accepted for publication pending revision following discussions of the meeting and post-meeting Science Advisory Report comment and review.

Compte rendu de l'examen régional par les pairs de l'évaluation du stock de hareng de l'Atlantique (*Clupea harengus*) dans les divisions 4VWX de l'OPANO

SOMMAIRE

Le hareng de l'Atlantique (*Clupea harengus*) est une espèce pélagique qu'on rencontre de part et d'autre de l'Atlantique Nord. La zone de gestion 4VWX de l'Organisation des pêches de l'Atlantique Nord-Ouest (OPANO) renferme plusieurs frayères du hareng. Aux fins d'évaluation et de gestion, la pêche du hareng dans la zone de gestion 4VWX est divisée en quatre composantes :

1) composante de reproducteurs du sud-ouest de la Nouvelle-Écosse et de la baie de Fundy (ou « 4WX » dans le plan de gestion);
2) composante de reproducteurs des bancs extracôtiers du plateau néo-écossais;
3) composante de reproducteurs des côtes de la Nouvelle-Écosse (rive sud, côte est et cap Breton); et
4) juvéniles migrateurs dans le sud-ouest du Nouveau-Brunswick.

La dernière évaluation du stock de hareng de la zone de gestion 4VWX a eu lieu en mars 2013 et a été suivie d'une mise à jour sur l'état du stock entreprise en mars 2014. Une réunion de consultation scientifique sur l'évaluation du stock de hareng 2015 dans la zone de gestion 4VWX a eu lieu les 25 et 26 mars 2015 à l'Institut océanographique de Bedford, à Dartmouth, en Nouvelle-Écosse. Deux documents de travail de réunion (relevés acoustiques et évaluation 2015) et avis scientifique sont présentés et soumis à la discussion. L'avis scientifique n'a pu faire l'objet d'un examen complet avant l'ajournement de la réunion. Les participants à la réunion conviennent que le scientifique principal, la présidente de la réunion et les pairs examinateurs du MPO désignés coordonneront la rédaction d'un rapport préliminaire devant rendre compte fidèlement des vues exprimées durant la réunion au sujet des documents de travail; ce rapport sera ensuite distribué par courriel à titre d'ébauche révisée de l'avis scientifique aux fins d'examen ultérieur et d'approbation après réunion. Tous les commentaires formulés au sujet du rapport distribué ont été examinés conjointement par le scientifique principal et la présidente de la réunion et ont été intégrés, au besoin. Dans l'ensemble, les participants estiment que l'avis scientifique et les documents de travail présentent de solides analyses scientifiques fondées sur la meilleure information disponible sur le hareng de la zone de gestion 4VWX. Les documents ont été acceptés pour publication sous réserve de leur révision pour tenir compte des discussions tenues durant la réunion, ainsi que des commentaires et révisions formulés après la réunion au sujet de l'avis scientifique.

INTRODUCTION

Atlantic Herring (*Clupea harengus*) is a pelagic species found on both sides of the North Atlantic (see: Power et al. 2013). Herring spawn in discrete locations to which they are believed to home. Herring mature and spawn at three to four years of age (23-28 cm), then begin a predictable annual pattern of spawning, over wintering, and summer feeding, which often involves considerable migration and mixing with members of other spawning groups. Fishing primarily occurs on dense summer feeding, over wintering, and spawning aggregations, and has been dominated by purse seine, weir, and gillnet gear types with relatively minor landings by shutoff, trap, and midwater trawl. The Northwest Atlantic Fisheries Organization (NAFO) 4VWX management unit contains a number of herring spawning areas, which are separated to various degrees both spatially and temporally.

In support of fishery management, Fisheries and Oceans Canada (DFO) Resource Management, Maritimes Region, requested that DFO Science undertake an assessment of the 4VWX herring management unit in support of the 2014/2015 fishery and, if possible, the 2015/2016 fishery. For the purposes of evaluation and management, the 4VWX herring fisheries are divided into four components:

1) Southwest Nova Scotia/Bay of Fundy (SWNS/BoF) spawning component (or '4WX' in management plan);
2) Offshore Scotian Shelf banks spawning component;
3) Coastal (South Shore, Eastern Shore and Cape Breton) Nova Scotia spawning component; and
4) Southwest New Brunswick (SWNB) migrant juveniles.

A new herring framework was adopted in January 2011 (DFO 2011a) followed by an assessment in April 2011 (DFO 2011b). Subsequent herring assessments occurred in February 2012 (Clark et al. 2012) and March 2013 (DFO 2013), with the 2012 assessment conducted as part of a broader review of Precautionary Approach Reference Points for a variety of fishery resources in the DFO Maritimes Region (DFO 2012). A stock status update was undertaken in March 2014 (DFO 2014).

A 4VWX herring stock assessment science advisory meeting was held March 25-26, 2015, at the Bedford Institute of Oceanography, Dartmouth, Nova Scotia. The meeting commenced as scheduled at 09:00 AM. After welcoming meeting participants (Appendix 1) through roundtable introductions, the meeting Chair, Mark Showell, provided a brief introduction. The Chair noted this was first and foremost a science peer review meeting, which means that the first responsibility of participants was to provide an objective review of the information that would be presented by the DFO Science assessment team. To assist in the review, two formal reviewers had been invited to attend the meeting: Dr. Jamie Gibson (DFO Science) and Ms. Irene Andrushchenko (DFO Science). The Chair noted there were a number of other invited participants with expertise and knowledge about herring and the herring fishery, and encouraged active participation in the meeting discussions. Secondly, the Chair noted that this was a DFO science advisory meeting, and the final product would be a Science Advisory Report (SAR). While DFO strives to achieve consensus on the main conclusions of the report, the final version would represent DFO Science advice to DFO Resource Management. The Chair also reminded participants that contents of the Working Papers, as well as meeting's discussion of results, were considered confidential and not to be circulated or cited prior to finalization.

The Terms of Reference for the meeting were reviewed (Appendix 2). The overall objectives of the meeting were to review and evaluate biological and fishery information on 4VWX herring stock status to assist with establishing a recommended quota for the 2014/2015 fishery and, if possible, for the 2015/2016 fishery, as required in the Integrated Fisheries Management Plan (IFMP), including but not limited to:

- An evaluation of the indicators for the Southwest Nova Scotia/Bay of Fundy spawning component.
- A compilation and review of information regarding the Offshore Scotian Shelf spawning component and the coastal Nova Scotia spawning component.
- An update on Southwest New Brunswick migrant juvenile fishery component.
- An evaluation of the status of the fishery with respect to the conservation Lower Reference Point.

Additional objectives of the meeting were to provide advice on the recovery and rebuilding of 4VWX herring, whether goals of the fishery rebuilding plan are being met, and to review reporting procedures to be used for stock status updates in the interim of the next formal science assessment of the stock. To address these objectives, two Working Papers were prepared. This meeting Proceedings report constitutes a record of discussion at the meeting. A SAR was also produced out of the meeting (DFO 2015). The meeting Agenda (Appendix 3) was reviewed prior to commencement of the meeting.

REVIEWS, UPDATES AND DISCUSSIONS

REVIEW: 2013 AND 2014 HERRING ACOUSTIC SURVEYS WORKING PAPER

Working Paper 1: Summary of the 2013 and 2014 Herring Acoustic Surveys in NAFO Divisions 4VWX (CSA Working Paper 2015/05)

Science Lead: R. Singh (Working Paper)

Rapporteur: K. Curran

Presentation Highlights

The science lead provided details on herring acoustic surveys conducted in 2013 and 2014, which were used to assess the status of the resource. Automated acoustic recording systems deployed on commercial fishing vessels have been used since 1997 to document the distribution and relative abundance of Atlantic Herring in the Bay of Fundy and coastal Nova Scotia area within NAFO divisions 4VWX. In 2013 and 2014, regularly-scheduled surveys at approximately 14 day intervals were conducted on the main spawning components, and the spawning stock biomass (SSB) for each component was estimated by summing the results. In 2013, seven structured surveys were conducted in Scots Bay, with six being conducted in 2014. Five usable structured surveys were conducted on German Bank in both 2013 and 2014. Two structured surveys were conducted in the Trinity Ledge area in both 2013 and 2014. There were no structured surveys conducted in 2013 or 2014 for Spectacle Buoy. In most instances, the surveys provided good coverage of the spawning areas consistent with established survey protocols. Although details of all surveys conducted in 2013 and 2014 were included in the Working Paper, in the interest of time, the science lead only presented selected survey results for illustrative purposes. It was demonstrated that the protocols employed for surveys in these years were consistent with the methodology used in past years, which has served to provide herring abundance time series from 1996-2014.

Discussion

The discussion primarily focused on survey results from the herring spawning components of Southwest Nova Scotia/Bay of Fundy. The science lead reviewed results of surveys for major and minor spawning areas in Bay of Fundy in 2013 and 2014. Spawning biomass trajectories through time for Scots Bay and German Bank were presented with error bars, which provided a sense of variability. It was noted that what is referred to as SSB in the Working Paper is not SSB in a traditional sense given biomass is estimated from acoustic surveys. In general, the Scots Bay spawning stock estimates have been slowly increasing since 2005, albeit with considerable variation around the estimates. A meeting participant noted the biomass in this component was high early in the time series. It was further noted that generation time for the herring resource is approximately one decade, and this should be considered when evaluating inter-annual variability. Discussion on specific spawning components of Southwest Nova Scotia/Bay of Fundy included:

Scots Bay Spawning

Surveys and spawning stock biomass for the Scots Bay major spawning component was reviewed. In 2013 and 2014, some survey transects were conducted outside of the survey box, which was noted to have occurred given that the distribution of the spawning stock was observed to be outside the designated survey box. It was noted that some data from the survey period was missing, and that the data could not be recovered, although improvements to the survey could be made in the future. No statistical test was performed to see if differences in abundance were significantly different between 2013 and 2014 survey results. It was noted that an increase in abundance of 300% is likely implausible biologically, although age data and error bars presented in figures of the Working Paper presented at the meeting would provide more insight into what was going on. The science lead noted that all survey estimates have variability, so focus should be on overall survey trends rather than detailed nuances within the results.

Information presented in the Scots Bay bubble plot of the Working Paper was discussed. The figure suggested that caution be taken in interpreting abundance of one of the surveys conducted in 2014 (i.e., the July 8th survey was much higher than all other surveys, so may have a large impact on the overall results). It was noted that the 2009-2010 year classes may be weak, reflected in subsequent landings in weirs (i.e., 2012), and that this weakness is being observed in Scots Bay (and to a lesser extent on German Bank). In contrast, anecdotal evidence provided by harvesters suggested a high abundance of herring in Scots Bay, which is consistent with the large survey observation on July 8, 2014. It was further noted that industry-led reductions implemented in 2006 were used to reduce removals from the area to allow for recovery. In general, from 1999-2014, Scots Bay biomass appeared to be larger earlier in the season relative to the past when larger biomasses were typically observed later in the survey year.

German Bank Spawning

Biomass trends for the German Bank spawning component were reviewed for the 2013 and 2014 surveys. It was noted that surveys less than 10 days apart were typically not included; there was concern that residency behaviour of herring might result in the same fish being surveyed more than once.

Trinity Ledge Spawning

It was noted that Trinity Ledge used to be a good spawning area, but good spawning estimates have not been observed in recent surveys. It was further noted that no acoustic surveys have been conducted recently in the minor spawning areas such as Seal Island and Browns Bank, although there is small fishery-related landings in these areas.

A Reviewer led a discussion regarding details of timing between sampling intervals. The primary concern was that fish abundance could be overestimated (double-counting) or underestimated (missing fish) using the acoustic survey approach employed in assessing the herring stock, and this should be highlighted as a source of uncertainty in the SAR. The science lead noted that studies have been conducted to evaluate double-counting, although no studies have been completed to account for fish that are not observed between surveys (i.e., missing fish). It was noted that the survey approach may not account for fish that enter the survey area to spawn, and subsequently leave, between the acoustic surveys of an area separated by 14 days.

Tagging studies have shown approximately 20% of fish that enter a survey area remain over 2 weeks, with 30-40% remaining in an area when surveys are separated by 9-10 days (conversely 0% remained when surveys were separated by 30 days). It was noted that a great deal of research has been conducted on this issue over the years, which is why surveys now occur at 2 week intervals. It was agreed fine-tuning may be required, especially to resolve potential under-counting, although it was recognized this could not be addressed for this stock assessment meeting. The science lead confirmed; however, that these issues would be assessed in more detail prior to the next framework assessment meeting for the resource; possibly exploring tagging and increased survey frequency to determine if appropriate factors could be applied to historic data, in hopes of improving the data set.

The discussion returned to what the acoustic survey estimates truly represented. The science lead indicated that they are assumed to represent SSB given the method only tracks adult fish. It was noted that this is different than how SSB is traditionally measured since, although it is assumed all fish are spawning, removals from the fishery are not accounted for using the herring acoustic survey approach. A meeting participant noted that in this instance surveys were conducted prior to commencement of the fishery. The science lead was then asked if there were any changes in protocols over the past year that might affect representativeness of the survey estimates. Meeting participants were assured standard protocols have been followed throughout the years and that the survey approach has remained consistent through time. General consensus of the meeting was that the acoustic survey method is good for purposes of the herring assessment, but should be explored further for possible refinement at the next framework meeting.

Revisions to the Working Paper proposed included: 1) an error in the biomass estimates table was noted and corrected; and 2) catch and landings are used interchangeably throughout the manuscript, so it was suggested for consistency and clarification that all references to 'catch' be changed to 'landings'.

REVIEW: 2015 HERRING EVALUATION WORKING PAPER

Working Paper 2:	2015 Evaluation of NAFO Divisions 4VWX Herring (CSA Working Paper 2015/06)
Science Lead:	R. Singh (Working Paper)
Rapporteur:	K. Curran

The presentation was separated into the four components of the fishery:

1) Southwest Nova Scotia/Bay of Fundy;
2) Offshore Scotian Shelf;
3) Coastal Nova Scotia; and

4) New Brunswick Weir and Shut-off. Much of the overall discussion focused on the Southwest Nova Scotia/Bay of Fundy component.

Southwest Nova Scotia/Bay of Fundy Component

Presentation Highlights

The 2015 evaluation of the NAFO Divisions 4WX herring considered data from the 2012-2013 and 2013-2014 quota years. Quota landings of herring in 2012-2013 were 46,554 metric tonnes (mt), and in 2013-2014 were 50,250 mt, against a total allowable catch (TAC) of 50,000 mt for each quota year for the Southwest Nova Scotia/Bay of Fundy component. Acoustic biomass estimates decreased by 28% in 2013 followed by a 37% increase in 2014 for this component. In 2014, the component's biomass estimate was slightly above the long term average. It was evident that most of the recent fluctuation in the Southwest Nova Scotia/Bay of Fundy spawning complex was occurring in the Scots Bay area despite an industry imposed catch restriction in this location. In 2013, the fishery catch-at-age composition by number was comprised of 34% fish at age 2, 21% at age 3, 9% at age 4, and 22% at ages older than age 5. In 2014, the fishery catch-at-age composition by number was comprised of 30% fish at age 2, 29% at age 3 years of age, 12% at age 4, and 21% at ages older than age 5. In 2013 and 2014, the proportion of the catch at age 5+ was the second and third highest proportion of age 5+ fish caught since 1994. It was noted that German Bank was the most important area in the spawning component, although it has seen decline over the past four years. A continued rebuilding strategy for this area was advised.

Catch-at-age by gear type was presented in summary tables. It was noted that different gears selected fish at different ages; in general, lots of age 2 fish were observed in the fishery in 2014. An increase in age 2 and age 3 abundances was noted, although this change was a proportion of total abundance and may not necessarily represent an increase in absolute abundance. In recent years, the age distribution has been spreading out across year classes, which reflects a number of changes in management measures implemented to facilitate rebuilding of the stock following a rebuilding plan put in place for the fishery. Industry has self-imposed a cap on juvenile (smaller) herring. The catch-at-age in the early-2000s would have had younger fish, so a broader distribution in fish ages is now being observed, reflecting changes in fishery management practices adopted through time, either by industry or DFO. Overall, there has been a reduction in the total number of fish in the landings from 2000-2014, from 7.6 million to 4.5 million, again due to changes in management practices adopted in the fishery in support of rebuilding of the stock. A levelling off of the number of fish landed over the past few years has been observed.

A reduction in weight-at-ages has been observed from the late-1970s to 2014, although there have been some increases in weight-at-age from 2010-2014. There was also a peak in weight-at-age observed in 1986; this is when the herring decline began, and perhaps represents a change in age-at-maturity (maturing earlier to compensate for losses in biomass that occurred at that time, although there is no science to support this possible explanation). Overall, it was noted that weights-at-age are still below historic levels.

Discussion

Landings from the Southwest Nova Scotia/Bay of Fundy component were discussed. At present, there is no analytical model of the herring population and, as a consequence, no absolute estimates of abundance or fishing mortality were available (including $F_{0.1}$, which was last estimated in the early-2000s as being 0.21). The largest source of landings in the component in 2013 and 2014 was from the purse seine fishery. Commenting on the relative decline of landings from German Bank specifically, it was noted by some meeting participants

from industry that after 2012 a self-imposed measure was put in place to reduce the proportion of the TAC that came from the Bank. Thus, noting that a decrease in landings from German Bank does not necessarily reflect a decrease in fish, rather a change in fishing effort to reduce pressure on the area (an industry-imposed 5000 mt catch limit in Scots Bay has been in place since 2005).

In terms of catch-at-age, it was again noted that additional management measures have been implemented by industry that place a cap on juveniles (< 23 cm) which can be landed (this has been implemented over the past 6 years). In addition, it was noted that an absolute cap on fish less than 18 cm being caught (with some tolerance) has also been put in place. Industry, through the Herring Science Council, tracks spawning and juvenile aggregates on a weekly basis to help industry avoid fishing areas occupied by small and/or juvenile fish. With this in mind, there was discussion regarding the juvenile portion of this component. The science lead noted that these areas are not well sampled by the acoustic survey gear, which cannot accurately detect age 1 and age 2 herring. Consequently, only the known spawning areas were surveyed. In the past, attempts have been made to develop a juvenile index for the species, although this work has been discontinued. That said, the DFO Summer Research Vessel (RV) survey does sample juvenile herring proximal to spawning grounds, although differences in gear type, mesh size, and fishing depth makes information from this survey series difficult to interpret.

Questions regarding numbers-at-age were raised. The science lead clarified that numbers-at-age are weighted by landings and not from the survey, and the large proportion of age 1 and age 2 fish observed in the 1960s was noted. It was clarified that during this period there were large numbers of these age groups despite having no quota limit along with a market for smaller fish. Further, a substantial fish meal fishery in the 1960s and 1970s focused on smaller fish. Notwithstanding, environmental conditions were good back then (i.e., food availability), with Trinity Ledge once being a very productive area. A question was raised about Trinity Ledge landings presented in the Working Paper; these seem to be misnamed or in error, as purse seine activity does not occur on Trinity Ledge. The science lead indicated that he would look into this potential error prior to finalizing the manuscript (following the meeting, the science lead provided maps of catches to show where they occurred on the Trinity Ledge fishing grounds).

It was noted that changes in commercial fishery weight-at-age could be driven by changes in timing of the fishery rather than a biological change. If it is timing of the fishery, then changes in productivity may not be occurring. It was noted that the spring fishery has changed, but that no major change in timing of the fishery through time would result in the changes being observed in the data. Two suggestions were made to improve the Working Paper regarding weight-at-age: 1) add an Appendix with a brief discussion of methods and results for routine age comparison studies against reference collections (these should include coefficients of variation between agers and any indication of bias/drift); and 2) conduct a review of historical data to look at possible differences in weights-at-age amongst different stocks. In terms of limit reference points and weight-averaged estimates, a minor change in the calculation of the three year average was noted by the science lead. As a result, years will be shifted to the left in the SAR when compared with results presented in Clark et al. (2012) and the previous herring Special Science Response Update (DFO 2014).

There was brief discussion regarding the calculation of exploitation rates on the spawning grounds. With an adjusted acoustic SSB, with transects in and outside the survey box, a reviewer inquired as to how biomass outside the survey box was adjusted to be included in SSB. The science lead noted that mixing of acoustic and landings data, which show different age compositions, may be having an impact. Further, the acoustic surveys exclude juveniles, while commercial landings throughout the year represent the entire distribution of fish.

It was agreed that the Working Paper should better characterize uncertainty in the annual estimates, and base conclusions on long-term trends rather than focusing on year-to-year differences (as error in survey and measurement may affect interpretation). It was noted that the data presented does not include confidence intervals, and this should be considered in drafting of the SAR, with a focus more on long term trends. Last, there were some specific suggestions to improve this section of the Working Paper:

1) Figure 13: 2014 panel for German Bank – 100 t difference should be accounted for (perhaps a typo);
2) Figure 7 and Figure 12 should have different symbols – increase aggregation and change symbols to help clarify fishing;
3) remove, redundancy in document – could be edited to reduce overall length of document (e.g. remove Figure 5); and
4) Figures 20A and 20B could be combined into one figure.

Offshore Scotian Shelf Component

Presentation Highlights

Landings from the Offshore Scotian Shelf bank areas continued a downward trend that began in 2012, with landings of only 1,515 mt in 2013 and 58 mt in 2014 being observed. There were only limited landings of herring from the bottom trawl and mid-water trawl (2014 only) gear in the Offshore Scotian Shelf banks areas for 2013 and 2014. No acoustic surveys were completed for the offshore area in 2013 and 2014. Herring abundance in the 2013 and 2014 DFO Summer RV survey remained relatively constant compared to all survey results since 2011. Overall, the area showed an increase in abundance from 2012 to 2013, followed by a subsequent decrease in 2014. The DFO Summer RV survey; however, is not considered indicative of overall abundance due to changes in catchability of herring and a lack of year-class tracking.

Discussion

There was discussion regarding landings levels for this component. In general, landings have been variable over the time series, but low in recent years. No additional survey information was available for this component, as surveys were not conducted in 2013 and 2014. It was noted that industry conducted searches for offshore herring aggregations in 2014, but failed to find spawning aggregations. There was discussion on the relevance of the current 12,000 mt TAC given the lack of recent information. It was noted by meeting participants that the 12,000 mt is based on previous science advice, which was thought to be a precautionary level in absence of additional abundance information. It was noted by the meeting Chair that discussion regarding decisions on future harvest levels is not a DFO Science issue rather a discussion to be held within the management forum.

DFO Summer RV survey herring catch rates from the offshore portion were discussed although, again, this information is not considered an index of abundance. This was determined at the last framework, as there is strong evidence that fish changed distribution in the water column during the survey rather than reflected a change in abundance. It was noted that the United States uses a trawl survey as a herring index, although this approach has been rejected in Canada. Herring bycatch catch-per-unit effort in the offshore silver hake fishery was mentioned as a possible index of herring abundance, and it was agreed this could be explored in preparation for the next herring framework assessment. Some meeting participants inquired if the offshore seiner fleet intended to conduct more science this year on the outer banks of the Scotian Shelf.

Industry noted that they are trying to find ways to pursue this, and it will be discussed at future Herring Science Council meetings.

Any impact of the offshore fishery on the inshore fishery was thought to be potentially important, and was discussed, as the distance between the inshore and offshore areas is only approximately 56 kilometres, with the offshore fleet typically concentrating on the inshore reaches of the offshore region.

Coastal Nova Scotia Component

Presentation Highlights

Landings in the gillnet and trap net fisheries along the coast of Nova Scotia increased from 2012-2014: 3,007 mt (in 2012); 3,937 mt (in 2013); and 4,760 mt (in 2014). Similarly, there was an increase in surveyed acoustic biomass in the Halifax/Eastern Shore area from an historic low estimate in 2012 of 3,668 mt to 6,870m t in 2013 and 9,586 mt in 2014 (2014 is near the five-year average of 10,664 mt). In the Little Hope area. there was an increase in 2013 to 74,532 mt, which is above a 4-year low of 12,756 mt observed in 2012. However, the surveyed biomass in the Little Hope/Port Mouton area again decreased to 46,077 mt in 2014, but still remained above the 5-year average of 37,664 mt. Only one survey was completed near Glace Bay in 2013 (50 mt) with no surveys completed in 2014. In the Glace Bay area, minimal landings were reported in 2013 (2 mt) and 2014 (1 mt). No herring surveys took place in the Bras d'Or Lakes area.

Discussion

A reviewer questioned whether the acoustic data had been corrected for selectivity. The science lead thought it had been corrected, but noted this would be verified for certainty prior to finalization of the Working Paper. The science lead further noted that during one of the surveys a moving school of herring was encountered. Questions subsequently arose over how this situation could be treated. In this case, no correction was possible, although this caveat would be noted along with the applicable data presented in the document. Discussion then focused on the target strength equation and how sensitive the biomass estimate is to the size frequency distribution of herring. This factor was thought to be significant (in the order of 3% per centimetre). It was further noted; however, that this potential bias is small relative to other uncertainties inherent in the survey data.

Additional questions arose regarding technical details of the acoustic survey methodology, as there was some concern expressed by some meeting participants that the acoustic protocol is not being applied uniformly across all spawning components (e.g. summation of surveys undertaken on 3 separate days in this component, when protocol says only surveys done 10-12 days apart are to be included in the analysis – scientists made this decision unilaterally). Meeting participants from industry further inquired if there had been progress in resolving the acoustic surface "dead zone", which in some instances could be 2-3 metres. It was noted that sonar could help identify this "dead zone", although interpretation would be difficult. It was further noted that new technologies coming to market in the next few years might be worth exploring for survey use. Industry participants were in favour of implementing any new survey instrumentation and techniques as soon as possible, further advocating for use of sonar immediately.

Minor revisions were requested on this section of the Working Paper: 1) quota for the coastal Nova Scotia fleet is based on a 5-year average – landings in 2013 were low, and effort was reduced in 2014 due to focus on lobster rather than herring – the Working Paper stated that 5-year and/or 10% for coastal Nova Scotia is used to determine a TAC, which is incorrect, with

reference to 10% to be removed from the manuscript; and 2) there was a request to add error bars to the landings and survey biomass plots, similar to those produced for the Southwest Nova Scotia/Bay of Fundy component. This would assist in interpretation of annual changes in the data. The science lead agreed both revisions could be completed. Last, vulnerability of the coastal Nova Scotia components was noted in the Working Paper, and it was suggested that no new areas should be opened to fishing unless enough information exists to do so. Meeting participants inquired as to what was meant by this statement and the science lead clarified that fishing should not occur in new areas just because herring might be observed to be present, rather sound science should be employed prior to opening up any new areas to fishing in this component.

New Brunswick Weir and Shut-off Component

Presentation Highlights

Landings in the New Brunswick weir and shut-off fishery were at a historic low of 504 mt in 2012. Landings increased to 6,431 mt in 2013 and then decreased to 2,149 mt in 2014; the second lowest landings for this fishery since 1963. In 2007, landings were 30,944 mt, which were the highest in nearly 20 years. The age distribution of fish caught in the New Brunswick weir and shutoff fishery were primarily juveniles, with 93% (2013) and 96% (2014) by numbers at either age 1 or age 2. The success of this passive trap fishery has been historically unpredictable and landings have declined markedly from the 1980s to present. Landings may not be indicative of abundance given they are extremely susceptible to many factors, in addition to abundance, including effort. In general, landings in this fishery are composed of small fish (age 1 and 2), which are thought to primarily originate from the NAFO Divisions 5YZ area.

Discussion

There has been a long-term decline in landings in this fishery since the 1960s, with current landings significantly below the long-term average. There was discussion on possible reasons for this decline given the number of weirs in use has also declined significantly since 1980s due to declining herring abundance in Southwest New Brunswick. It was postulated the decline in landings may be related to lower abundance of herring, lower effort, or both, although currently the science does not exist to answer in any definitive manner.

UPDATE: COLLABORATIVE RESEARCH

Powerpoint PPT:	Adaptive and Neutral Genetic Variation in Spring- and Fall-spawning Herring, *Clupea harengus*, in the Northwest Atlantic
Science Lead:	A. Fuentes-Pardo
Rapporteur:	K. Curran

Presentation Highlights

The presenter, Angela P. Fuentes-Pardo, is a PhD Candidate of Dr. Daniel Ruzzante, Department of Biology, Dalhousie University, Halifax, Nova Scotia. The presenter provided a summary of her science research related to herring in the Northwest Atlantic. Briefly, sustainable fishery management relies on the delimitation of fish stocks that account for biological features of the species of interest, in order to maintain its diversity and population dynamics despite fishing. Traditional methods for fish stock identification have included morphometry, tagging data, and life history traits. With the development of modern molecular techniques, such as massive parallel high-throughput sequencing (or Next Generation Sequencing), population genomics has become a very promising approach to identify fish stock

boundaries, even for species with expected large effective population sizes, as is the case for Atlantic Herring, where traditional neutral markers have provided little resolution.

As part of the presenter's PhD dissertation, it is intended that the following questions will be addressed:

1) what is the spatial scale of population structuring among herring spawning grounds?;
2) are there genetic differences between spring and fall spawners?;
3) to what degree are these genetic differences temporally stable?; and
4) to what degree have environmental features influenced the observed genetic patterns?

The science lead has secured temporally-replicated (i.e., year 1, year 2, year 3, etc.) samples of spawning herring covering the reproductive range of the species in the Northwest Atlantic (from Newfoundland, Canada, to Maine, U.S.A.). A whole genome re-sequencing of pools of DNA at six locations has been conducted to identify informative Single Nucleotide Polymorphisms that will allow estimation of the spatial scale of population structuring of herring in the Northwest Atlantic. For future genetics studies, the use of muscle tissue as a source of DNA is recommended rather than fin-clips, due to the high degree of degradation observed in the latter.

Discussion

Fish stocks in general are described by a range of criteria: historical distribution; environmental signatures; genetics; and population. To date, most genetic studies on herring have occurred on stocks in the Northeast Atlantic (e.g., Baltic Sea). In Baltic Sea fisheries, markers to differentiate between fish occupying different temperatures and salinities have been observed. However, it is not possible to distinguish populations occupying the same temperatures and salinities. Further, the biology of herring is complicated given their population sizes are large and mobile; it is difficult to find genetic differences between spawning components. Thus, what is to be expected of the genetic study of herring? Based on experiences with Atlantic Cod, differences in inshore and offshore Northern Cod could be identified and it is believed similar patterns may be observed for herring.

In terms of herring, it is important to catch spawning herring. As such, it would be a benefit to find differences between herring in Scots Bay, Bay of Fundy, and German Bank, if possible. The proposed regional study would look at genetics of herring samples from certain spawning grounds given herring exhibit a homing behaviour:

1) Northumberland Strait (spring);
2) Northumberland Strait (fall);
3) Inner Bay of Chaleur;
4) Fortune Bay;
5) Bonavista Bay; and
6) German Bank.

These six populations represent the range of herring in Atlantic Canada, as well as, a combination of spring and fall spawners. It was agreed that an analysis of this nature is of value, given it might contribute to improved understanding of population structure of herring in the Northwest Atlantic.

DISCUSSION: INTERIM UPDATE REPORTING PROCEDURES

DFO Canada has adopted an 'interim update' science assessment procedure whereby the assessment cycle of a given fish stock includes a framework assessment, stock assessment, and stock update in interim years between framework and stock assessment meetings. Interim updates focus on agreed upon indicators of stock status, and the peer review is held within the Department (no external participation). Given external participation is not incorporated into interim update assessments, meeting participants sought discussion on implementation of this approach for the herring fishery given industry funds several elements of science undertaken in support of the stock. In general, industry representatives are supportive of the overall interim update approach, but would prefer interim updates reports of greater detail, as well as, a process that allows for external participation.

In 2014, the most recent interim update for herring, the science lead presented results of the update to industry prior to hosting the internal science peer review meeting. In addition, supplementary documents containing figures (without text) were also provided to industry representatives for that year. Although appreciated, industry representatives expressed concern that the supplementary documents were not peer reviewed. Industry representatives agreed that in off years there is no need for their participation in a meeting; however, they would still request opportunity to provide input into interim update reports prior to finalization, as well as continue to have opportunity for on-going dialogue with DFO scientists during interim years. This would include:

- input into update reports prior to peer review/finalization; and
- access to documents that the science lead produces.

In general, industry expressed frustration given the significant industry-led support for herring science, yet absence of adequate opportunity to participate in the science and peer-review meetings during interim years. The meeting coordinator Kristian Curran committed to a continued dialogue regarding the role of industry in interim years in support of the science assessment of herring. Further, the meeting coordinator communicated the views of industry to the Regional Director of Science, Maritimes Region, Dr. Alain Vézina, for further awareness.

REVIEW: SCIENCE ADVISORY REPORT

Rapporteur: Kristian Curran

Discussion

The Chair introduced Day 2 of the meeting, and new meeting participants introduced themselves. Following this, the Chair provided a summary of presentations and discussion from Day 1 of the meeting. The science lead then worked through the proposed SAR for the meeting. There were a number of general comments and suggestions for improving future SARs:

1) the SAR should be more focused and reduced in length and content, so the important messages are not lost in excessive text;

2) much of the current SAR provided great detail on inter-annual changes between recent years, but did not provide interpretation of long-term trends (this should be addressed in future iterations of the SAR); and

3) some participants found reading the SAR confusing, as the document jumped around through different periods of time (future versions require a strict editorial review).

There were a number of specific suggestions also made for improving the current version of the SAR:

- Terminology in Table 3 "temporal diversity of spawning" required clarification, as meeting participants were not clear as to what this actually meant (diversity in length of a given spawning period, diversity in seasonal spawning, long-term diversity in spawning behaviour, etc.).
- Table 3 in general required a review in terms of where the criteria came from and what they actually mean (e.g. what does "maintain biomass at moderate to high levels" – how is moderate and high defined – unclear at the moment).
- It should be clearly identified in tables, figures, and text in the section 'Offshore Scotian Shelf' what numbers include (e.g., do not include herring bycatch tonnage from other non-herring directed fisheries). Add 12,000 mt line to Figure 10 – agreement on this provided bycatch is correctly denoted in the figure caption.
- Should better capture the carry-forward of uncertainty in various estimates presented. Confidence Intervals to be included in the table presented in the SAR rather than having accompanying numbers presented in text (Table 2).

The SAR underwent significant revision during the assessment meeting. As a result, it was not completed prior to meeting adjournment.

Process for Reaching Consensus

The SAR presented at the meeting did not receive complete review prior to meeting adjournment, although those sections of the SAR of greatest importance to meeting participants were reviewed during the meeting. It was agreed by meeting participants that the science lead, meeting Chairperson, and formal reviewers would coordinate completion of the remaining sections of the draft SAR not addressed at the meeting consistent with views expressed in the meeting on the Working Papers. The draft report was then circulated as a revised SAR by email for subsequent review and approval on those sections that did not receive consensus during the meeting. It was further agreed that content in the report that reached consensus at the meeting was not be open to further revision unless identified to be scientifically incorrect. A completed draft SAR was circulated via email on April 9, 2015, to all Day 2 meeting participants for review by April 17, 2015. All comments provided on the circulated draft SAR were addressed, and incorporated as necessary, jointly by the science lead and meeting Chair. The SAR was subsequently deemed to have reached consensus.

CONCLUSIONS

Meeting participants felt the SAR and Working Papers presented sound scientific analyses based on the best available information on 4VWX herring. The documents have been accepted for publication pending revision following discussions of the meeting and post-meeting SAR comment and review. Sincere efforts were made in this science peer review process to acknowledge and address all comments and concerns raised by meeting participants provided they were appropriate and within the confines of acceptable peer review practice.

REFERENCES CITED

Clark, D.S., K.J. Clark, R. Claytor, S. Leslie, G.D. Melvin, J.M. Porter, M.J. Power, H.H. Stone, and C. Waters. 2012. Limit Reference Point for Southwest Nova Scotia / Bay of Fundy Spawning Component of Atlantic Herring, *Clupea harengus* (German Bank and Scots Bay). DFO Can. Sci. Advis. Sec. Res. Doc. 2012/025: iii + 14 p.

DFO. 2011a. Proceedings of the Maritimes Region Science Advisory Process on the Assessment Framework for Southwest Nova Scotia/Bay of Fundy Herring; 24-28 January 2011. DFO Can. Sci. Advis. Sec. Proceed. Ser. 2011/031: iv + 28p.

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DFO. 2013. 2013 Assessment of 4VWX Herring. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/045.

DFO. 2014. 4VWX Herring 2014 Update Report. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/029.

DFO. 2015. 2015 Assessment of 4VWX Herring. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2015/040.

Power, M.J., D. Knox, A. MacIntyre, G.D. Melvin, and R. Singh. 2013. 2011 Evaluation of 4VWX Herring. DFO Can. Sci. Advis. Sec. Res. Doc. 2012/085: iv + 85 p.

APPENDICES

APPENDIX 1: LIST OF MEETING PARTICIPANTS

Participant	Affiliation
Andrushchenko, Irene	DFO Maritimes / Population Ecology Division (SABS)
Baker Stevens, Nellie*	Eastern Shore Fisherman's Protective Assn. (ESFPA)
Baker, Lori*	Eastern Shore Fisherman's Protective Assn. (ESFPA)
Boone, Brian	NB Dept. Agriculture, Aquaculture & Fisheries
Brown, Reid	Fundy Weir Fishermen Association
Chandler, Alan	NS Dept. Fisheries & Aquaculture / Marine Fish
Clay, Allen	Femto Electronics Limited
Curran, Kristian	DFO Maritimes / Centre for Science Advice Maritimes (CSAM)
Dalton, Alexander	DFO Maritimes / Population Ecology Division (SABS)
d'Entremont, Kim	Comeau's Sea Foods Limited
d'Eon, Glen	Southwest Seiners Co.
d'Eon, Sherman	Cape Breeze Seafoods Ltd.
Ellis, Chad	Atlantic Herring Co-op
Francis, Cory	Confederacy of Mainland Mi'kmaq (CMM)
Fry-Buchanan, Joy	Atlantic Herring Co-op
Fuentes-Pardo, Angela*	Dalhousie University / Biology
Gibson, Jamie	DFO Maritimes / Population Ecology Division (BIO)
Grant, Catharine	Ecology Action Centre (EAC)
Hooper, Tony	Connors Bros., Clover Leaf
Hussey-Bondt, Laura**	DFO Maritimes / Resource Management
Kaiser, Tim	Scotia Garden Seafood Inc.
Kent, Don*	Eastern Shore Group
Larkin, Donna	Southwest Seiners Co.
McNeely, Joshua	Maritime Aboriginal Peoples Council (MAPC) - IKANAWTIKET
Melville, Guy	Brier Island Whale and Seabird Cruises (BIWSC)
Melvin, Gary (WEBEX)	DFO Maritimes / Population Ecology Division (SABS)
Robicheau, Lloyd*	Eastern Shore Fisherman's Protective Assn. (ESFPA)
Ruzzante, Daniel*	Dalhousie University / Biology
Saulnier, Billy	Comeau's Sea Foods Limited
Saulnier, Brian	SeaCrest Fisheries
Showell, Mark	DFO Maritimes / Population Ecology Division (BIO)
Singh, Rabindra	DFO Maritimes / Population Ecology Division (SABS)
Stirling, Roger	Seafood Producers Assn of NS (SPANS)
Storch, Ana	Herring Science Council

* Participant did not attend Day 2 of the meeting.
** Participant did not attend Day 1 of the meeting.

APPENDIX 2: MEETING TERMS OF REFERENCE

Assessment of 4VWX Herring
Regional Peer Review - Maritimes Region

March 25-26, 2015
Dartmouth, N.S.

Chairperson: Mark Showell

TERMS OF REFERENCE

Context

Maritimes DFO Resource Management has requested that DFO Science undertake an assessment of the 4VWX herring management unit in support of the 2015/2016 fishery and, if possible, the 2016/2017 fishery. A new herring framework was adopted in January 2011 (DFO 2011a) followed by an assessment in April 2011 (DFO 2011b). Subsequent assessments occurred in February 2012 (Clark et al. 2012) and March 2013 (DFO 2013). The 2012 assessment was conducted as part of a broader review of Precautionary Approach Reference Points for a variety of fishery resources in the DFO Maritimes Region (DFO 2012). The most recent science advice was conducted as an update in March 2014 (DFO 2014).

Objectives

Review and evaluate biological and fishery information on 4VWX herring stock status to assist with establishing the final quota for the 2014/2015 fishery and, if possible, for the 2015/2016 fishery, as required in the Integrated Fisheries Management Plan, including but not limited to:

- An evaluation of the indicators for the southwest Nova Scotia / Bay of Fundy spawning component.
- A compilation and review of information regarding the offshore Scotian Shelf spawning component and the coastal Nova Scotia spawning component.
- An update on southwest New Brunswick migrant juvenile fishery component.
- An evaluation of the status of the fishery with respect to the conservation Lower Reference Point.

In addition, provide advice on the recovery and rebuilding of 4VWX herring, whether goals of the fishery rebuilding plan are being met, and review reporting procedures to be used for stock status updates until the next formal assessment.

Expected Publications

- Science Advisory Report
- Proceedings
- Research Document

Participation

- DFO Science
- DFO Resource Management
- Provincial government (fisheries)
- Herring fishing industry
- Aboriginal communities/organizations

References

Clark, D.S., Clark, K.J., Claytor, R., Leslie, S., Melvin, G.D., Porter, J.M., Power, M.J., Stone, H.H., and Waters, C. 2012. Limit Reference Point for Southwest Nova Scotia / Bay of Fundy Spawning Component of Atlantic Herring, *Clupea harengus* (German Bank and Scots Bay). DFO Can. Sci. Advis. Sec. Res. Doc. 2012/025: iii + 14 p.

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DFO. 2011b. 2011 Assessment of 4VWX Herring. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2011/046.

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DFO. 2014. 4VWX Herring 2014 Update Report. DFO Can. Sci. Advis. Sec. Sci. Resp. 2014/029.

APPENDIX 3: MEETING AGENDA

Assessment of 4VWX Herring

Regional Peer Review – Maritimes Region

March 25-26, 2015
Lewis King Boardroom
Bedford Institute of Oceanography, Dartmouth, NS

Chair: Mark Showell

DRAFT AGENDA

DAY 1 (Wednesday, March 25, 2015 – Lewis King Boardroom, BIO)

09:00 – 09:15	Welcome, Introduction, and Review of Agenda
09:15 – 10:00	Nova Scotia / Bay of Fundy spawning component
10:00 – 10:15	Break
10:15 – 12:00	Nova Scotia / Bay of Fundy spawning component (continued)
12:00 – 13:00	Lunch (Not Provided – Cafeteria On-site)
13:00 – 14:45	Review of Offshore Scotian Shelf spawning component, and coastal Nova Scotia and New Brunswick coastal components
14:45 – 15:00	Break
15:00 – 16:00	Update on DFO/Industry Collaborative Research
16:00 – 16:30	Review of Interim/Update Reporting Procedures

DAY 2 (Thursday, March 26, 2015 – Lewis King Boardroom, BIO)

09:00 – 09:15	Review of Previous Day
09:15 – 10:15	Review of 4VWX Science Advisory Report
10:15 – 10:30	Break
10:30 – 12:00	Review of 4VWX Science Advisory Report (continued)
12:00 – 13:00	Lunch (Not Provided – Cafeteria On-site)
13:00 – 14:45	Review of 4VWX Science Advisory Report (continued)
14:45 – 15:00	Break
15:00 – 16:15	Update on DFO/Industry Collaborative Research
16:15 – 16:30	Close of Meeting